

January 31, 2014

Mr. Michael Burke, Plant Manager

Holyoke WPCF

One Berkshire St.

Holyoke, MA 01040

Subject: 2014 (Year of 2013) Annual Review of Nitrogen Removal (Part I.H. Special Conditions, NPDES Permit No. MA0101630) for Holyoke, MA WPCF

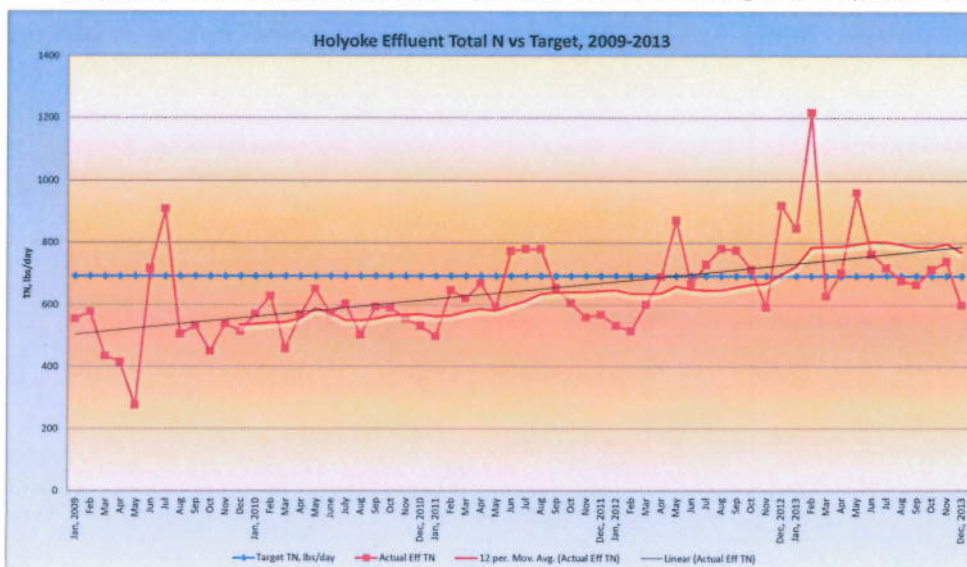
Introduction

The NPDES Permit for the Holyoke Water Pollution Control Facility requires that the facility submit annually a report on performance of the Holyoke WPCF in removing nitrogen. The average annual (baseline) effluent target for Total Nitrogen (TN) load for the Holyoke WPCF is listed as 696 lbs/day. Nitrogen optimization aims to maintain or reduce effluent nitrogen below or at this baseline. This is the third annual Nitrogen Review for the Holyoke Water Pollution Control Facility. In prior years the Target TN load was met but in 2012, and again this year, 2013 the average effluent TN was 1% over target, with 2012 averaging 701 lbs, and 2013 averaging 11% over target at 772 lbs/day, consistent with long term upward trends in influent TKN loads. Influent TKN in 2012 averaged 1,364 lbs/day, up 8% from 2011, while influent TKN for 2013 averaged 1,660 lbs/day, up 22% from 2012. In this context, holding the effluent TN increase to 11% is fairly good performance.

Earlier reports on optimization strategies and TN reduction describe significant facility limitations and present past data with respect to effluent Nitrogen and process control, optimization strategies employed, and results. This annual report continues to build on previous reviews by adding 2013 data and considering recent changes and new challenges.

Results of Optimized Operational Practices (2013)

After the initial operational review in 2009 the operators incorporated their experiences into a revised high flow management plan and process control plan and went on into longer term operational practice. The attached table



(page 6) is updated from that provided in last year's annual review to include results from the 2012 year of operations.

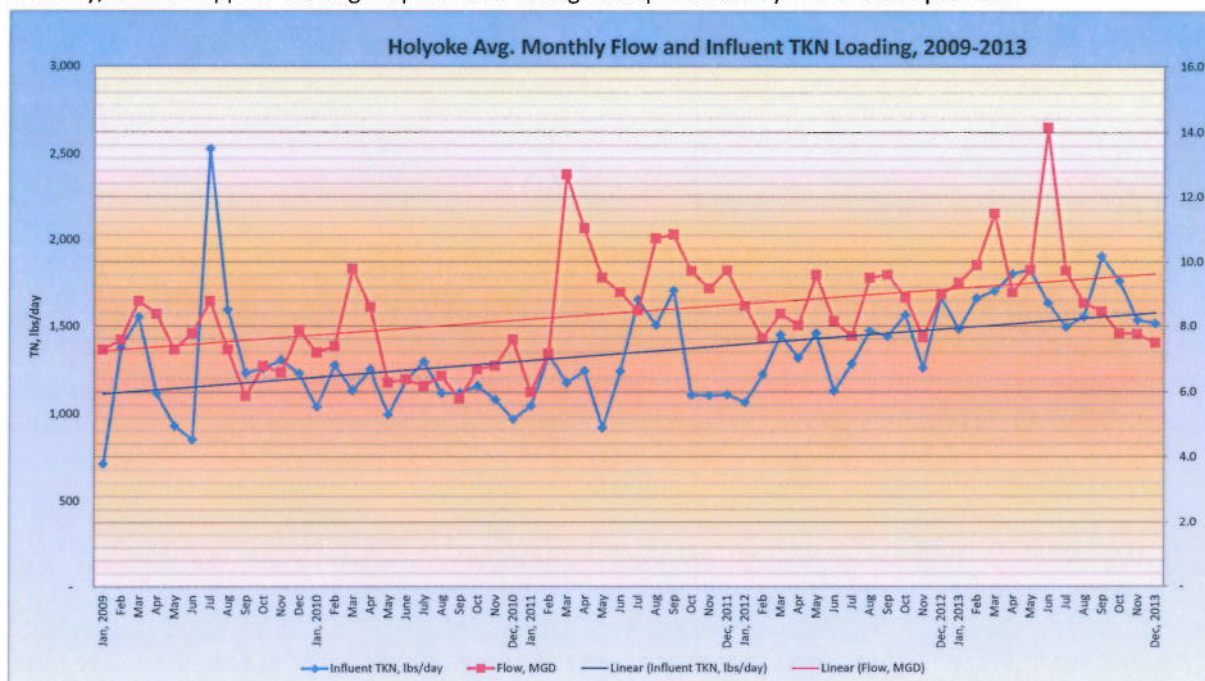
Operational data for the recent 12 month period shows a continuing increase in effluent Total N over the five year period (to left). While six of twelve months in 2012 exceeded goal, some 8 of 12 months

exceeded the 696 lbs/day goal in 2013. The annual average effluent total N concentration was 9.96 mg/L up from 9.77 mg/L, in 2012 some 46% of average annual influent TKN (down from 49% in 2012).

Effluent TKN averaged 9.3 mg/L after averaging 8.6 mg/L in 2012. High Organic (refractory N) has been a problem in prior years and continued to challenge operators in 2013. Effluent organic (refractory) N concentrations were 3.0 mg/L or higher in five of twelve months during 2013 with monthly average Organic N peaking at a very unusual 8.5 mg/L in February, the same month effluent TN peaked at 14.7 mg/L and 1,219 lbs/day. The remaining cause of increased TN relative to 2012 was due to higher effluent ammonia-N concentrations, up from an average of 5.7 to 6.4 mg/L, continuing an upward trend from 2012. The facility operated at a higher average Food to Microorganism (F/M) ratio in 2013, increasing from 0.12 in 2011 and 0.16 in 2012 (up 33%) to 0.19 mg/L in 2013 (up another 19%, consistent with 22% higher influent TKN loadings). Influent BOD and TKN loadings have both been increasing.

Year to year flows were up from 8.6 to 9.5 MGD (10%), matching influent flows in 2012, but influent BOD's roughly matched 2012 and influent BOD loadings were up by 11% or so. Primary effluent BOD's were also up over 2012. To the extent operators can maintain higher MLSS levels they can offset the challenge somewhat but to the extent TKN increases continue, operators are essentially operating at the design limits of the plant and have no good options for contending with such increases. This year the secondary factor of increasing primary effluent BOD and TKN loads increased the challenge to consistently hold down effluent TN. Interestingly, as we'll note later, performance with respect to effluent BOD and TSS were up slightly but still good.

The graph below presents average monthly flow and influent TKN loadings to the Holyoke facility. Note the clear upward trend in influent wastewater flow, and also in influent TKN loads. This graph illustrates how successful the Holyoke facility has been at capturing higher volumes of wastewater since the new CSO facility went on line and similarly, it would appear that higher pollutant loadings as represented by TKN are also present.



Average annual flows, BOD and TSS concentrations and loads for the three years have been as follows:

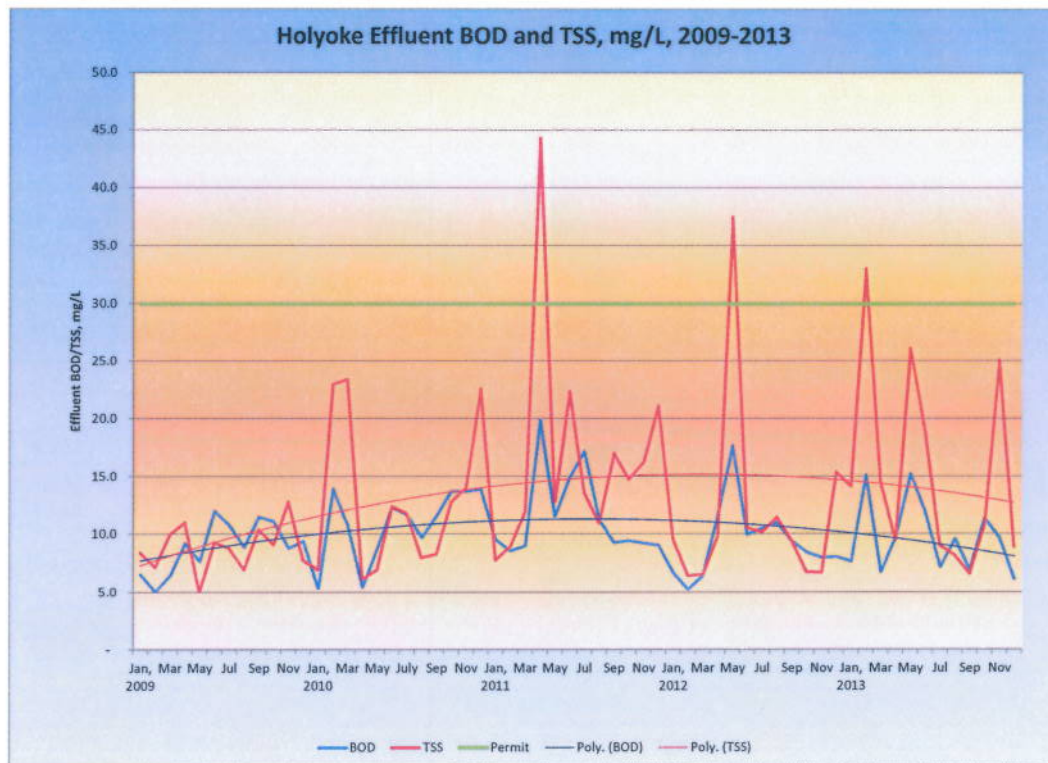
Year	Flow, MGD	BOD, mg/L	TSS, mg/L	TKN, mg/L	Influent BOD, lbs/day	Influent TSS, lbs/day	Influent TKN, lbs/day
2009	7.5	236	267	20.8	14,762	16,701	1,310
2010	7.1	187	189	19.6	11,073	11,191	1,139
2011	9.5	151	170	16.4	11,963	13,469	1,265
2012	8.6	170	164	19.1	12,193	11,762	1,364
2013	9.5	174	185	21.6	13,786	14,657	1,660

2013 saw the highest monthly average flow in 5 years at 14.2 MGD! While nitrogen loadings have increased over the entire five years, BOD and TSS loadings have been variable and perhaps declining somewhat (7% for BOD and 12% for TSS) from 2009 to 2013. Higher effluent nitrogen values would seem to be driven more by higher flows, higher PE BOD, and higher influent TKN, and judging from the effluent nitrogen species tracked, from an increase in refractory (difficult to degrade), "organic" nitrogen.

The Holyoke facility treated maximum flow rates of 40 MGD during 8 of 12 months in 2012, up from 7 months in 2011. In 2013 the plant was within 1 MGD of max flow all 12 months of the year! Average flow was up year to year, dropping from 9.5 to 8.6 MGD in 2012 but was back up to 9.5 MGD in 2013. As the facility flow rates have increased towards design capacity, effluent BOD and TSS concentrations increased during the first three years, but in 2012, the operators' decision to reduce MLSS levels and operate with lower secondary sludge blankets seems to have paid off.

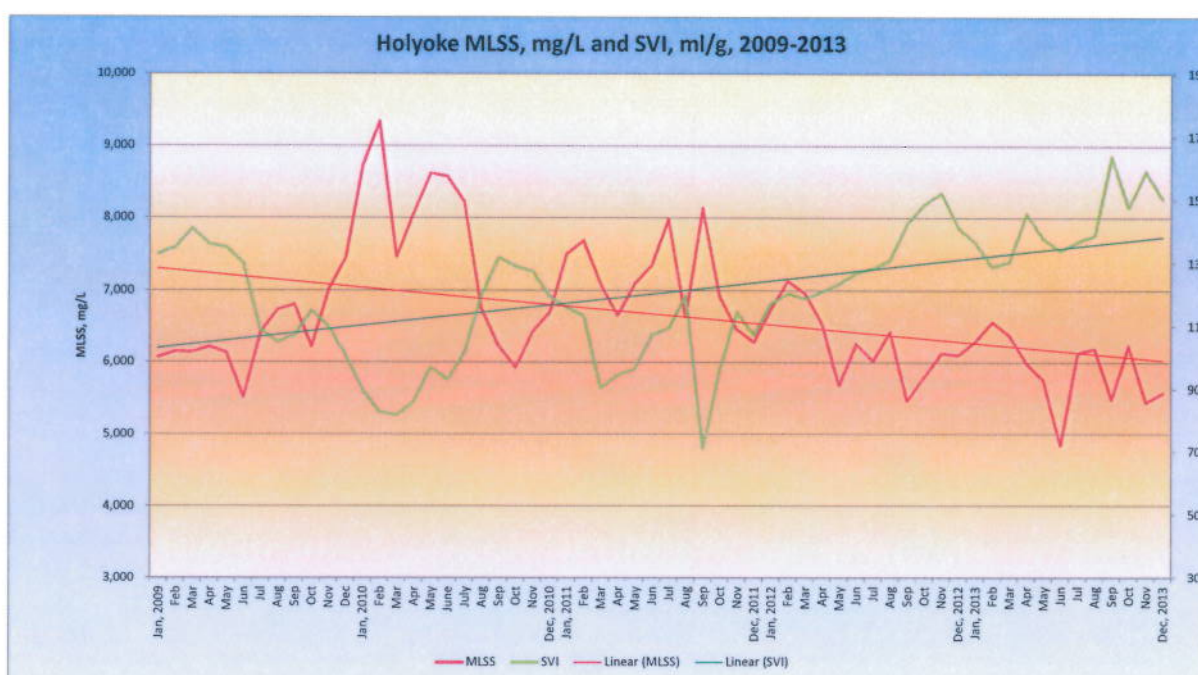
In 2013 effluent BOD and TSS concentrations were up from an average of 9.4 mg/L for BOD in 2012 to 9.8 mg/L this year, and from an average of 11.7 mg/L for TSS in 2012 to an average of 15.4 mg/L this year.

Effluent pH levels were below 6.5 for 5 of 12 months, suggesting low effluent alkalinity levels. Since influent TKN loads are increasing and effluent pH levels are marginal



(low) it may be worth tracking influent and effluent alkalinity twice a month in 2013 to collect enough data to indicate whether there are developing alkalinity limitations to nitrification performance going forward.

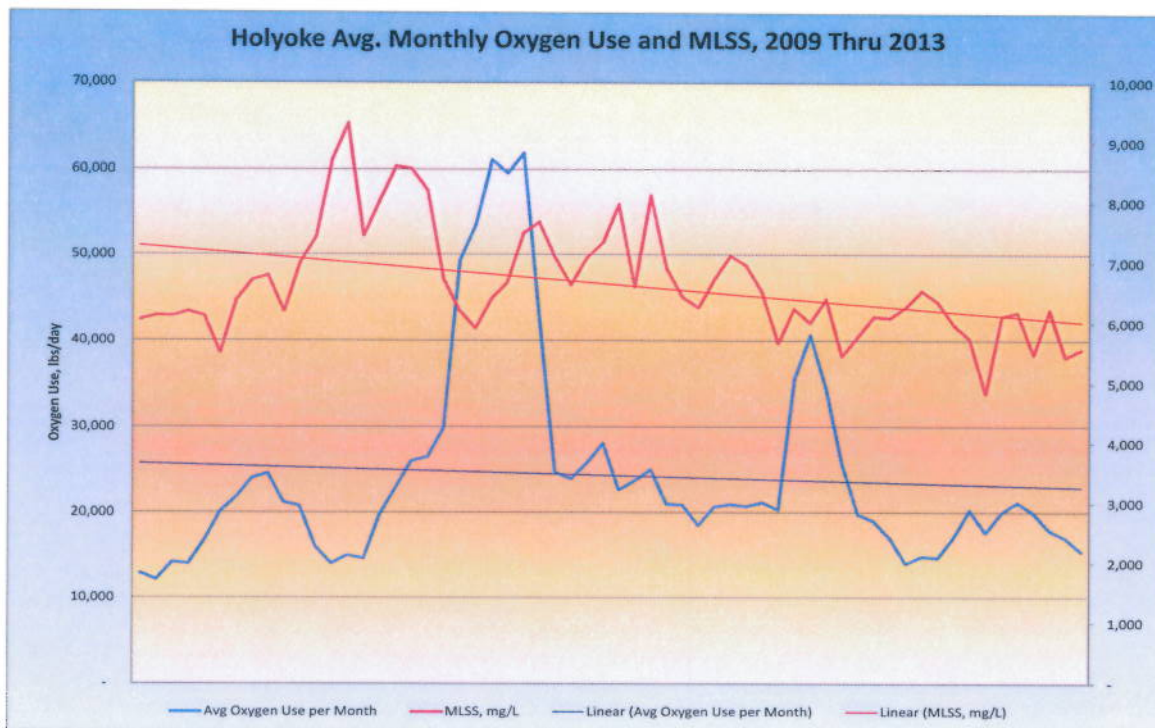
In 2013 both the downward trend in MLSS and the upward trend in Sludge Volume Index (SVI) continued from 2012 (see graph below). 2011 was the lowest year of the five for SVI at 103 ml/g, but this year's SVI's averaged 143 ml/L and was the highest for the five years, up from 2012's 131 ml/g. MLSS concentrations dropped from 7,154 mg/L in 2011 to 6,296 mg/L in 2012 to 5,909 mg/L last year, down another 6%, although still high relative to most activated sludge plants. Balancing optimization of effluent BOD and TSS, with optimization of effluent TN, the operators may have struck a happy medium in 2012 which had somewhat better effluent quality than this past year, 2013.



Even at 5,900 mg/L, MLSS, Holyoke's operators are still running at very high concentrations for mixed liquor suspended solids, and long sludge ages (9 to 10 days) in order to maximize the capacity of the short detention time oxygen activated sludge system of this facility. Should influent flows and loads continue to increase operators will clearly not be able to meet effluent nitrogen targets. It may be helpful to operate at higher MLSS concentrations and higher MCRT's, perhaps aiming for 6,300 to 6,500 mg/L for MLSS and running 10 days for MCRT.

Surprisingly, Waste Activated Sludge (WAS) production averaged 5,728 lbs/day for 2013, down from 6,050 lbs/day in 2012 even though the average F/M was up by 19%. Oxygen usage has occasionally been a problem in past years but was down by 7,180 lbs/day (30%) in 2013 to 17,527 lbs/day (see graph next page). The primary advantage of running at lower MLSS levels may be in lowered demand for oxygen as this chart would suggest. While running slightly higher on MLSS may produce slightly better effluent quality the current results with the exception of TN are well under goal, and reduced oxygen use not only saves money but reduces the required

energy off site to generate oxygen. The chart shows a clear improvement in consumption of oxygen over prior years.



Other Observations and Recommendations

Effluent nitrate and nitrite concentrations have dropped even further relative to past years averaging just 0.48 mg/L for Nitrate down from 0.97 mg/L last year, and averaging 0.17 mg/L for nitrite down from 0.19 mg/L in 2012. Maintaining low nitrate concentrations to hold down effluent Total Nitrogen, a problem for many secondary treatment facilities, has not been a problem for the Holyoke plant. Following the data summary table on page 6 you will find four additional graphs, two showing trends over the 5 year period (monthly and max flows, and effluent pH and ammonia) and two showing rough correlations (MCRT vs Effluent TKN, and F/M vs Oxygen Use). An expanded plot of effluent total N loadings over the past 5 years, including a running 12 month average, as shown earlier in this report is also included on page 8.

Submitted:

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Recent Operational Data (2009-13)

Holyoke WWTF

Updated Feb. 2013 with Year End 2013 Data

Month	Avg Infl. Flow MGD	Int. Max. Flow MGD	Int. BOD ₅ mg/L	Int. TSS ₂₀ mg/L	Pri. Eff. BOD ₅ mg/L	Pri. Eff. TSS ₂₀ mg/L	Sec. Eff. BOD ₅ mg/L	Sec. Eff. TSS ₂₀ mg/L	Sec. Eff. pH	Sec. Eff. DO ₂ mg/L	F/M Ratio	Sludge Ret. Time Days	Return Sludge MGD	Return Sludge %	WAS ₁₀ DO ₂ mg/L	Q ₂ Use, lbs/day	Influent NH ₄ -N mg/L	Influent Organic-N mg/L	Effluent NH ₄ -N mg/L	Effluent Organic-N mg/L	Effluent TN mg/L	Effluent TN, lbs/day			
Jan. 2009	7.3	31.8	186	171	113	113	6.6	8.4	7.3	6.6	0.075	0.11	5.5	10.3	14.2%	6,134	12,322	11.7	712	9.0	0.04	5.13	249		
Feb	7.4	30.5	155	149	91	91	5.1	7.2	7.3	6.7	0.135	0.10	12.3	30.8	14.2%	6,468	12,303	21.6	1,379	9.0	0.02	0.01	5.14	379	
Mar	8.1	35.7	134	188	87	87	4.8	10.9	7.3	6.6	0.143	0.10	9.7	31.0	12.5%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Apr	8.8	37.7	124	188	87	87	4.8	10.9	7.3	6.6	0.143	0.10	9.7	31.0	12.5%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
May	7.3	33.8	120	220	152	152	7.7	11.8	7.3	6.5	0.143	0.10	9.7	31.0	12.5%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Jun	7.8	38.4	294	207	141	141	11.1	11.1	7.3	6.5	0.143	0.10	9.7	31.0	12.5%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Jul	8.8	39.6	303	249	141	141	11.1	11.1	7.3	6.5	0.143	0.10	9.7	31.0	12.5%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Aug	7.3	40.0	426	241	147	147	8.0	7.0	7.0	6.4	0.105	0.13	10.6	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Sep	5.9	35.5	289	207	156	156	11.5	10.4	7.1	6.4	0.105	0.13	10.6	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Oct	6.8	38.7	190	193	137	137	11.1	9.1	7.1	6.5	0.115	0.14	11.6	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Nov	6.6	38.7	203	138	137	137	8.8	12.8	7.0	6.5	0.115	0.14	11.6	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Dec	7.2	35.8	146	182	128	128	9.4	7.0	7.0	6.6	0.101	0.12	11.6	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Jan. 2010	7.4	32.1	140	176	134	134	13.0	23.0	7.2	6.6	0.13	0.10	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Feb	8.8	34.8	171	187	138	138	11.1	21.1	7.2	6.6	0.101	0.10	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Mar	8.8	34.8	171	187	138	138	11.1	21.1	7.2	6.6	0.101	0.10	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Apr	6.3	30.7	120	185	133	133	8.8	7.0	7.2	6.6	0.101	0.10	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
May	6.3	30.7	120	185	133	133	8.8	7.0	7.2	6.6	0.101	0.10	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Jun	6.2	31.7	212	238	133	133	11.7	12.8	7.1	6.5	0.101	0.10	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Jul	6.5	31.6	207	257	207	207	9.7	8.0	7.0	6.4	0.102	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Aug	6.5	31.6	207	257	207	207	9.7	8.0	7.0	6.4	0.102	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Sep	5.8	31.3	270	211	213	213	10.7	8.3	7.0	6.4	0.102	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Oct	6.7	31.6	277	211	213	213	10.7	8.3	7.0	6.4	0.102	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Nov	6.8	31.0	212	152	164	164	11.7	13.7	7.1	6.4	0.102	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Dec	7.6	31.6	234	152	151	151	11.5	22.8	7.1	6.7	0.102	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Jan. 2011	6.0	34.0	220	191	234	234	9.0	7.8	7.3	6.6	0.106	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Feb	6.0	34.0	220	191	234	234	9.0	7.8	7.3	6.6	0.106	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Mar	6.0	34.0	220	191	234	234	9.0	7.8	7.3	6.6	0.106	0.12	11.5	31.0	10.6%	6,105	14,209	21.2	1,556	6.5	14.7	5.8	4.3	5.94	416
Apr	11.0	31.0	47	154	72	72	19.9	44.3	7.1	6.5	0.08	0.11	10.2	31.0	10.2%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
May	9.5	37.5	90	139	34	34	11.5	12.8	7.2	6.5	0.07	0.11	10.2	31.0	10.2%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Jun	9.1	40.0	126	155	108	108	12.0	22.4	7.2	6.5	0.07	0.11	10.2	31.0	10.2%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Jul	8.5	40.0	240	239	138	138	12.0	22.4	7.2	6.5	0.07	0.11	10.2	31.0	10.2%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Aug	10.7	40.0	130	189	126	126	11.3	11.0	7.1	6.4	0.109	0.13	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Sep	10.8	40.0	130	189	126	126	11.3	11.0	7.1	6.4	0.109	0.13	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Oct	9.7	40.0	134	118	87	87	9.4	14.8	7.7	6.6	0.107	0.13	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Nov	9.2	40.0	153	201	85	85	9.2	16.3	7.2	6.5	0.115	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
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Mar	8.0	31.5	179	181	137	137	11.6	9.8	7.2	6.4	0.11	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Apr	8.0	31.5	179	181	137	137	11.6	9.8	7.2	6.4	0.11	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
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Jun	8.2	40.0	129	187	122	122	10.0	10.9	7.0	6.4	0.127	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
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Sep	9.6	40.0	136	180	128	128	11.0	11.5	7.0	6.4	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Oct	9.6	40.0	187	178	170	170	11.0	11.5	7.0	6.4	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Nov	7.7	34.6	200	207	172	172	8.0	6.8	7.1	6.5	0.132	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Dec	9.4	40.0	133	129	124	124	11.0	11.5	7.0	6.4	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Jan. 2013	9.4	40.0	133	129	124	124	11.0	11.5	7.0	6.4	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Feb	9.4	40.0	133	129	124	124	11.0	11.5	7.0	6.4	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Mar	11.5	39.9	141	134	110	110	10.8	10.8	7.2	6.5	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
Apr	9.1	39.9	151	201	133	133	10.8	10.8	7.2	6.5	0.131	0.14	10.3	31.0	10.3%	5,455	25,370	11.1	1,388	4.7	0.05	0.17	5.87	432	
May	9.8	40.0	187	217	137	137	10.																		

Holyoke Effluent Total N vs Target, 2009-2013

